

The modern Changes
of the
Earth and its Inhabitants
considered as illustrative of Geology.

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The present century has been fruitful in the growth of all knowledge, and perhaps of none more than of geological knowledge. During the last forty years the facts of geology have accumulated immensely, and the birth of theories has at least kept pace with the multiplication of facts. Enormous tracts of the earth's surface, in Asia, Africa, America and Australia, remain yet wholly unexplored — still larger areas are hopelessly hidden from our eyes by the abysses of the ocean — but the greater part of Europe is at least generally known to us, and limited areas here and there have been examined and described with a minute and exhaustive perseverance which leaves little to be desired. Defective as the materials of geology still are, they have been incalculably increased during the period before named. Countries which were but scratched here and there by the pickaxe of the quarryman or the miner have been laid open in all directions by the long cuttings of the railway — and an increased number of workers have sprung up everywhere to study effectually the splendid sections thus exhibited.

It is no wonder, then, that those who wrote on this subject half a century since if still living amongst us, see the need of keeping their former opinions abreast of the

growth of knowledge. One great living authority in this country — Sir C. Lyell, whose first work, the „Principles of Geology“ was published as far back as 1830, has in the interval seen fit to publish nine successive editions, every one of them being more or less a revision of the first. And this same author, now verging on old age, has, as he himself states it, owing to the rapid growth of knowledge, been led during the year lately past, to re-write a very considerable portion of his treatise — and the student of geology may therefore assume that we have in it the final and deliberate opinions which have been garnered from his long and varied experience.

But revisions and alterations and additions, do not of necessity imply any change of theory. They do imply the explanation and assimilation of many new facts, and some changes of opinion, — one of which, is of high importance, viz the manner in which particular changes have been brought about — and which I shall notice hereafter.

The one principle upon which, in my judgement, the study of this science should be based, is simply the uniformity of natural forces through all time. This terraqueous globe of ours has never, throughout the countless ages registered by geology, been subject to any agencies materially different from those which are now acting upon it. Of course, its aspect, at different intervals, has been widely different.

Land and sea, mountain and valley, have changed places, and all have been tenanted at different times by widely different populations. But these various aspects

have not succeeded each other abruptly. They are not the product of successive destructions and creations. If we could read the whole unbroken history, we should see these various pictures melting quietly and gradually into one another like the dissolving views in a magic lantern, or rather, for even this comparison indicates changes too sudden and complete, they would be like the shifting landscapes which seem to slide past the spectator as he reclines in a railway carriage, in which there is no actual division, because at each instant the end of one scene constitutes the beginning of another. This is the view of geology which is known as the Uniformitarian.

It was not the theorie of the earliest geologists, nor is it the one which naturally presents itself as the most probable at first sight. When men first began to examine the architecture of the earth, and found strata which had evidently been deposited horizontally, raised obliquely or even vertically, and sometimes crumbled in folds like a sheed of paper — when they saw that mountain chains had burst up through the plain, tossing the adjacent rocks like dust from their flanks; — when they found that almost all the existing land had lain for centuries at the bottom of seas of various depths — when they came upon the traces left by the action of tremendous fires, which had rent rocks and baked or crystallised whole mountains — it is no wonder if they leapt to the conclusion that this earth had been repeatedly the scene of giant catastrophes and devastating convulsions, such as we have never experienced in these later days. And this conclusion seemed yet more certain when they found, by the examination of the fossils inclosed in different strata, that

earth and seas were peopled at different periods by wholly different forms of vegetable and animal life. Surely, they argued, we have here the record of distinct and successive creations. Each one served its turn and lasted its time. Each one was destroyed at its appointed period by some universal scourge of flood or fire, and from the world, thus reduced anew to chaos, a fresh and different creation again and again emerged. This theory — known as that of the Convulsionists — still survives in the nomenclature which speaks of the Primary, Secondary, Tertiary and Modern Periods of Geology. It is implied in a system of reconciliation, probably still very popular, which interposes an indefinite gap between the first and second verses of the first chapter of Genesis, for the sake of limiting the period which follows to the Modern or Human Period. That period is supposed to be described in the rest of the chapter as emerging from the chaos which succeeded to the breaking up of the Tertiary Period. But these views, plausible as they seemed at first, have been gradually giving way before the acquisition of wider and more accurate knowledge — and the opposite theory, the Uniformitarian, may now be considered as absolutely triumphant with all the more philosophical geologists.

Sir Roderick Murchison, perhaps alone among distinguished names, still upholds, though with many qualifications, the position of the elder school. But, Sir C. Lyell, to whose work I have already referred, shows by a careful induction of observed and recorded instances, that the whole earth, steady as it seems, is still in a perpetual flux — that land and sea are still, as of old, gaining and losing on one another — that continents are still sinking,

and ocean-beds are still uprising — that rains and winds, frost and snow and ice are still scooping, moulding, undermining, scratching, breaking, and piling up portions of the earth's crust, exposed or unexposed to view. Give these quiet agencies only time to act in, and they are amply sufficient to produce enormous results. But these are not all. There are yet more tremendous and appalling powers at work around us. The Uniformitarian theory is sometimes stated in such a way as to exclude from its operation the volcans, the deluge, or the earthquake. That, however is clearly a mistake. These causes operate now, and may therefore be supposed to have operated always, without disturbing the uniformity of nature. Within the last year or two the wave of an earthquake has rolled round the globe, sometimes felt only as a mysterious quivering, sometimes engulfing cities and deluging islands and continents with the waters of the sea tossed upwards from their bed. Volcanic eruptions are still pouring out streams of lava, which alter the face of the landscape for miles around. These are among the ordinary forces of nature working now, as they have ever worked, and producing from time to time along the vast procession of uncounted age tremendous, though always limited and local, effects — „There can be no doubt (writes Sir C. Lyell) that periods of disturbance and repose have followed each other in succession in every region of the globe — but it may be equally true, that the energy of the subterranean movements has been always uniform as regards the whole earth. The force of earthquakes may for a cycle of years have been invariably confined, as it is now, to large but determinate spaces, and may then have gradually shifted

its position, so that another region, which had for ages been at rest, became in its turn the grand theatre of action“.

These are all causes that we know, and if they are sufficient in the lapse of ages to bring about the required results, it is unphilosophic to imagine other causes, about which we know nothing, to account for them.

Another set of considerations, however, arising from a different quarter, has been lately suggested, and which ought not altogether to be passed over. The precession of the equinoxes, the variation in the exentricity of the earth's orbit, and in the obliquity of the ecliptic, are ascertained facts. They all affect slightly the relative positions of the earth and sun. Do they therefore affect the temperature and the climates of the earth? Because if they do, their effect may be supposed to become perceptible during the long ages of which geology treats. And again, the sun itself, with its attendant planets is supposed to be ever sweeping its own vast orbit through surrounding suns and systems. Does it, in its course, as it approaches and recedes from these, traverse regions of different temperature? Is empty space itself differentiated by the quicksilver of the thermometer? Must causes like these be taken into account, when we attempt to follow back the chain of geological causation into its remote distances? Even if we do consider them, it is obvious, to remark that we are not thereby infringing the Uniformitarian theory. These are causes which are in operation now, though the vastness of the time required for their manifestation prevents us from taking any note of them in the present. Their effect is so small in comparison with other forces that they may be

practically neglected. Yet there is one of them to which some consequence ought to be assigned, that is, the variation in the excentricity of the earth's orbit.

This, Sir Charles Lyell thinks may possibly have helped to intensify the cold of the glacial period — and he gives in his work a curious table, compiled by Mess. Croll and J. C. Moore, which, on that supposition, assigns a definite date to that period, and places it about 800,000 years ago. All this, however, is extremely uncertain, and must take its place and share its fate with other similar guesses and approximations.

These considerations seem sufficient to give at least a high probability to the Uniformitarian hypothesis that all things have been from the beginning as they are now. But this reasoning has as yet been applied only to inorganic nature. Does it hold equally true of organisation and life? For geology has its tale to tell of these also. Enclosed within its rocks are the fossil records of many a fauna and flora as distinct as possible both from one another and from any thing we see now. What is the meaning of this? Are there any causes at present at work, insensibly modifying the plants and animals around us, so that in the progress of ages they may be changed into quite different plants and animals, just as we have seen that there are causes now at work sufficient in the course of time to change our seas and continents into other continents and other seas? If there are not, the Uniformitarian theory breaks down at this point, and we must admit that while it accounts for the changes in the crust of the earth itself, it does not account for the changes in the inhabitants which people it. It may give a sufficient history of the mineral kingdom — it will not

furnish the clue to the annals of the vegetable animal kingdoms. Such an argument, however, cannot readily be admitted. There are clearly only two ways in which the difficulty can be met by one who refuses to believe that there has been from time to time a clean sweep of the existing fauna and flora, and an entirely new one substituted in their place. He must say, either that all the species of plants and animals, like the hills and rivers of the earth, are ever in a state of perpetual and indefinite variation — or, that species are perpetually dying out singly, and their places perpetually refilled by ever fresh acts of creation.

The latter alternative is that which has usually been adopted. Linnaeus long ago, pronounced the dogma — „*Classis et ordo est sapientiae, species naturae opus*“ — and also said some what oracularly — „*Species tot numerus quot diversae formae in principio sunt creatae*“. And our greatest geologists, giving perhaps more than due weight to his words, did not venture to doubt the invariability of species. Sir C. Lyell, writes thus on the subject — „In former editions of my work, from 1832 to 1853.“ I did not venture to differ from the opinion of Linnaeus, that each species had remained from its origin such as we now see it, being variable, but only within certain fixed limits.

The mystery in which the origin of each species was involved seemed to me no greater than that in which the beginning of all vital phenomena on the earth is shrouded. But I undertook to show that the gradual extinction of species one after another was part of the constant and regular course of nature, and must have been so throughout

all geological time, because the climate, and the position of land and sea, and all the principal conditions of the organic and inorganic world, are always, and have been always, undergoing change.

I pointed out how the struggle for existence among species, and the increase and spread of some of them, must tend to the extermination of others; and as these would disappear gradually and singly from the scene, I suggested that probably the coming in of new species would in like manner be successive, and that there was no geological sanction for the favourite doctrine of some theorists, that large assemblages of new forms had been ushered in at once to compensate for the sudden removal of many others from the scene“.

How these new species were introduced was a matter which he did not even attempt to explain. It was sufficient if he could give any probable reasons for the obscurity and uncertainty of their introduction. — „As the death of the last representative of a species would be abrupt, I conjectured that the birth of new forms might be equally so, but as I had entire faith in the doctrine that what is now going on in the natural world affords a true indication of what has been and will be, I assumed that the coming in of new species must be going on at about the same rate as the dying out of old ones — and I therefore felt myself called upon to explain how the birth of new species could be always in progress, and yet the botanist and zoologist remain wholly unconscious of the occurrence of events so wonderful, and to them of such transcendent interest“.

It was a difficult problem. And though the considerations adduced from the enormous variety of species and the

extent of our ignorance, which could never allow us to say that any given species was newly born into the world, because it was newly discovered by us, did something towards softening the difficulty, they could not be said to have removed it. In this strait it is easy to see how welcome to the perplexed Uniformitarian must have been the promulgation of Mr. Darwin's theory. For this afforded the very solution which was required. If all forms of life are in a perpetual state of indefinite variation, if under the strict conditions of the struggle for existence old species are for ever melting away by imperceptible gradations into new, the problem is satisfactorily explained. The analogy of nature is complete — the law of change which rules the inorganic world is found to regulate the organic world also. The same principle of adaptations of general forces, which has piled strata upon strata of different rocks in endless succession, has also peopled these strata with the memorials of ever varying shapes of life. We cannot wonder, therefore that the Uniformitarian eagerly embraces this theory. Indeed it is the illustration and the defence of it which constitute the chief distinction of Sir C. Lyell's last edition.

Dr. Hooker in his recent address to the members of the „Royal Geological Society“ passed a very high eulogium on that distinguished author, and stated that Sir Charles, after having devoted whole chapters of the first edition of his „Principles of Geology“ to establishing the doctrine of special creations, abandons it in the tenth edition, and this, too, on the showing of a pupil. „And then added“, I know no brighther example of heroism, of its kind, than this, of an author thus abandoning, late in life, a

theory which he had for forty years regarded as one of the foundation-stones of a work that had given him the highest position attainable amongst contemporary scientific writers. Well may he be proud of a superstructure raised on the foundations of an insecure doctrine, when he finds that he can underpin it and substitute a new foundation; and after all is finished survey his edifice not only more secure, but more harmonious in its proportions than it was before; for assuredly the biological chapters of the tenth edition of the „Principles“ are more in harmony with the doctrine of slow changes in the history of our planet, than were their counterparts in the former editions“.

It is very interesting to trace — with the aid of Sir C. Lyell's work — the origin and progress of these new ideas.

There is Lamarck's theory, which appeared in the early part of this century, but never gained any considerable or open acceptance. The calm was first broken in England by the appearance in 1844, of the „Vestiges of Creation“. That was followed by an essay from Mr. Alfred Wallace, in 1855, the fruit of his explorations on the river Amazon, with Mr. H. W. Bates. It was entitled „On the Law which has regulated the Introduction of New Species“, and its reasoning were summed up in the proposition „that every species has come into existence coincident both in space and time with a pre-existing closely allied species“. Meanwhile Mr. Darwin had been for many years at work in the same direction. Ever since his voyage in the „Beagle“, he had been amassing materials and writing memoirs on the subject. Several of his manuscript volumes on the subject had been read by Dr.

Hooker as far back as 1844, and how long the ever-accumulating store of facts and reasonings might have remained unknown to the general public, had no one else attempted to work out the same problem, it is impossible to say. But in 1858, Mr. Darwin received a communication from Mr. Wallace, then in the Malay Archipelago, in which views so entirely coincident with his own were expressed, that it seemed unfair to allow it to go forth to the world alone. Accordingly, by the advice of Dr. Hooker and Sir C. Lyell, Mr. Wallace's memoir and a chapter from the yet unpublished „Origin of Species“ were read together before the Linnaean Society. The ice being thus broken, it needed only a little more pressure to induce Mr. Darwin to put his views fully before the public, though he could only do so as yet in the abridged and condensed statement of the famous volume which is even yet only supplemented by the first part of its apparatus of proof. These are pleasant facts, in as much as they exhibit a rare instance of joint discoverers working out their common views in harmonious co-operation, undisturbed by the bitter jealousies which everywhere disfigure the annals of science, and which, if only the subject were equally popular, would probably have made „odium physicum“ a term as familiar to our ears as „odium theologicum“.

Although Mr. Darwin's reasonings make it appear in the highest degree probable that the changes of the organic world may have been effected by the gradual and insensible modification of older pre-existing forms, yet it cannot be said that they absolutely prove it. The thoughtful and serious student cannot however, fail to notice in

the writings of these eminent men the expression of a reverent and humble admiration of the inscrutable ways of the Divine Author of nature, as well as to mark the direction and rate of progress of instructed opinion in physical and biological science.



